

CDEFFS

ANSI/NIST Committee to Define an Extended Fingerprint Feature Set

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April 2006

Charter

In the ANSI/NIST ITL 1-2000 Standard Workshop II (Dec. 2005), the committee was chartered to:

- Identify, define and provide guidance on additional fingerprint features beyond minutiae (not limited to level-3 detail)
- Develop draft Addendum to ANSI/NIST ITL-2006
- Cooperate with SWGFAST and AFIS vendors
- Report back by December 2006

Committee

Includes 28 people from 14 organizations — Open to new members

- Behnam Bavarian (Motorola)
- John Burt (NEC)
- Jeri Eaton (King County WA)
- Brian Finegold (BAE)
- Jean-Christophe Fondeur (Sagem Morpho)
- Mike Garris (NIST)
- Ed German
- Mike Gilchrist (FBI-CJIS)
- Paul Griffin (Identix)
- Masanori Hara (NEC)
- Austin Hicklin (Mitretek)
- Tom Hopper (FBI-CJIS)
- Anil Jain (Michigan State)
- Artour Karaguiozian (Motorola)
- Peter Komarinski (IAI)
- Debbie Leben (US Secret Service)
- Bill Long (TBS)
- Brian Martin (Identix)
- Mike McCabe (NIST)
- Glen McNeil (Sagem Morpho)
- Steve Meagher (FBI-Lab)
- Geppy Parziale (TBS)
- Scott Swann (FBI-CJIS)
- Anne Wang (Cogent)
- Phillip Wasserman (NIST)
- Kasey Wertheim (Lockheed Martin (DOD))
- Brian Wong (IBG)
- Stephen Wood (NIST)

SWGFAST Concern

- “AFIS technology, since its onset, has utilized a very limited amount of fingerprint detail. Latent print experts must rely on far more information in effecting individualizations/exclusions than just ending ridges and bifurcations, i.e., the Type 9 minutiae record. SWGFAST is attempting to educate and provide to the vendor community the additional features and how they are utilized by these experts.”
- *(from Nov. 2005 memo to NIST)*

Extended Features Under Consideration

Overview

Extended Features Under Consideration

Level 1 Features

- a. Ridge flow
- b. Cores and deltas
- c. Finer level of classification

Level 2 Features

- a. Ridge path elements
- b. Open field of ridges
- c. Greater definition of minutiae
- d. Scars
- e. Creases
- f. Incipient ridges
- g. Dots

Level 3 Features

- a. Pores
- b. Ridge edge shapes/width

3d Features

- a. Ridge height / valley depth

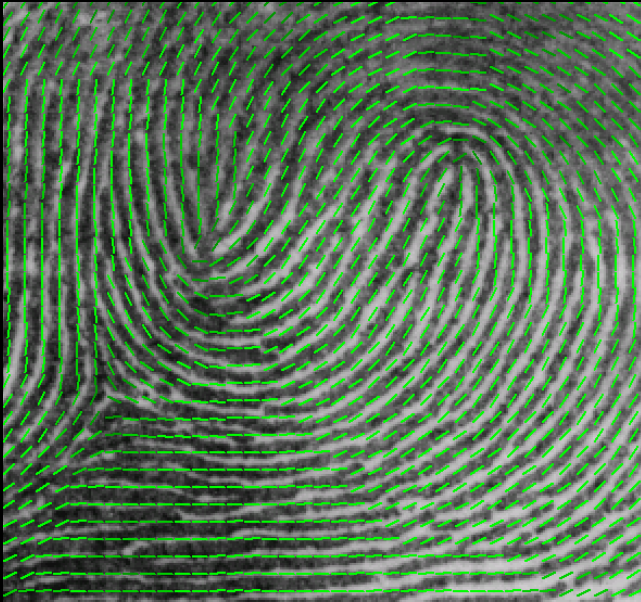
Issues

- For each type of feature, the issues are
 - Concurrence on
 - precisely what is meant
 - definition in ANSI/NIST fields
 - Repeatability / reliability / stability
 - Practicality of
 - automatic detection
 - human detection
 - Use/value
 1. Human comparisons
 2. Human-encoded AFIS searches
 3. Fully automated encoding and matching?

Possible Uses

- Areas of improvement for feature extraction and matching algorithms (both for latent and non-latent fingerprints)
- Interoperability of fingerprint feature definitions
- Quantification of the features actually used in latent comparison
 - Human examiners would be able to detail more precisely the non-minutiae features used for comparison (for courtroom, Daubert use, etc.)
 - Improved feature set for use in modeling uniqueness of fingerprints
- Basis for special-purpose latent end-stage matcher
 - A matcher that might require human markup of both fingerprints being compared, but would quantify similarity

1a: Ridge flow



- Adjacent friction ridges in a directional arrangement
- Basically pattern classification of a limited area
 - Role of traditional pattern classification is diminishing as AFIS moves from rolls to flats
- Used in some AFISs for screening
 - to exclude candidates, but not for identification
- Used by some matchers by itself

- ***Most encoders use a similar process***
- ***The M1 Finger Pattern proposed standard could be used as a model for definition***

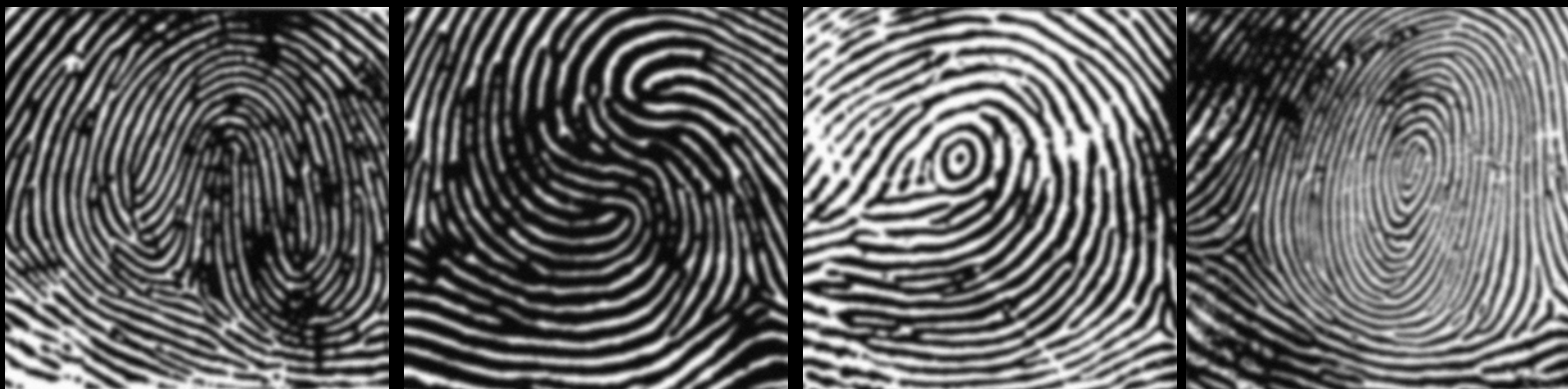
1b: Cores and Deltas



- Cores and deltas are underutilized in AFIS technology
- Core and delta position, shape, and relationships are all of use
- Using minutiae and ridge flow direction in areas of high curvature would address some of the issue
- Location of cores is useful / necessary in determining the centering of a fingerprint

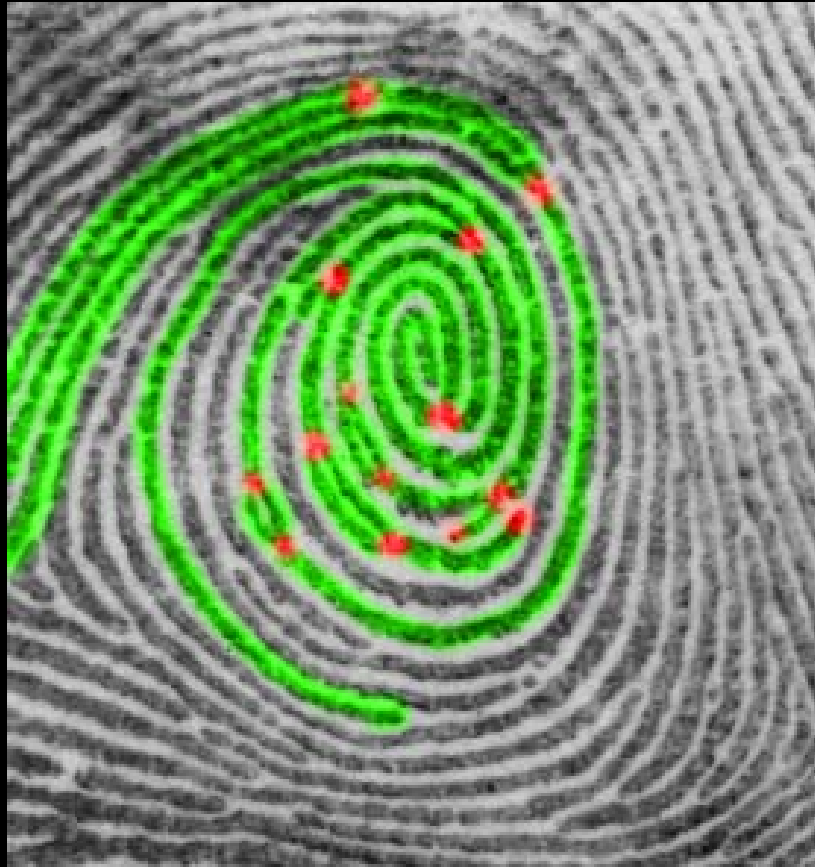
- ***Minutiae within these areas should be more extensively used***
- ***Otherwise, definition will need concurrence, and detection will need research***

1c: Finer level of classification



- The old Henry Classification was extremely beneficial to latent print searching
- AFIS processing uses a simplified model, due to
 - the limited benefit a finer level of classification provided
 - The difficulty of accurate automatic pattern classification to this level
- ***The definition of these (via Henry or NCIC) is well defined, but for human classification***
- ***Automatic detection at this level is an unsolved problem, and generally requires rolls***

2a: Ridge Path (1 of 2)



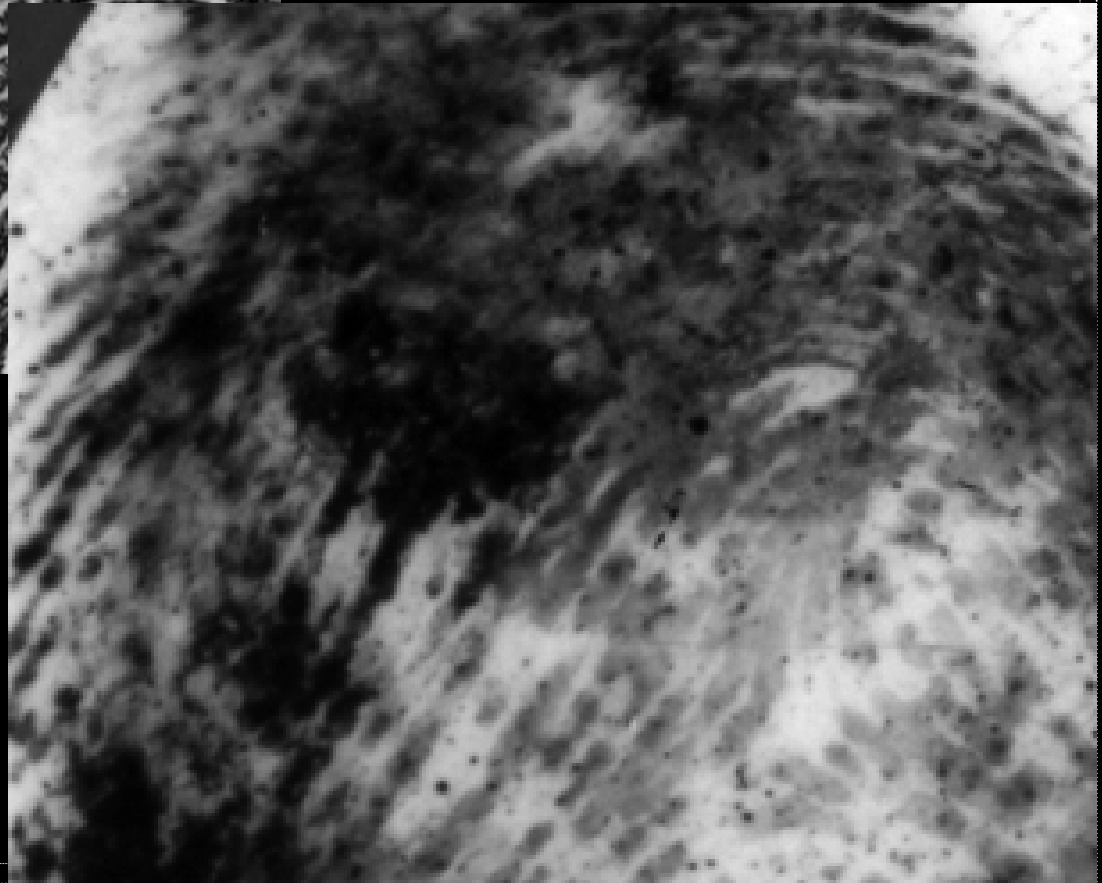
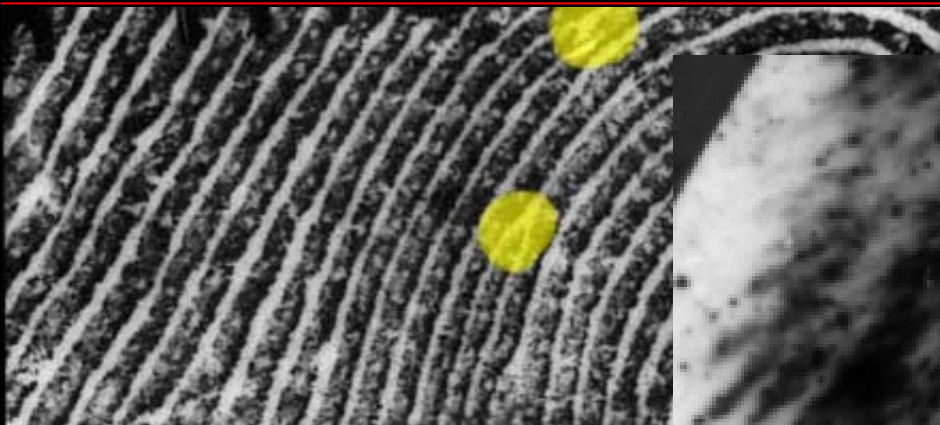
2a: Ridge Path (2 of 2)



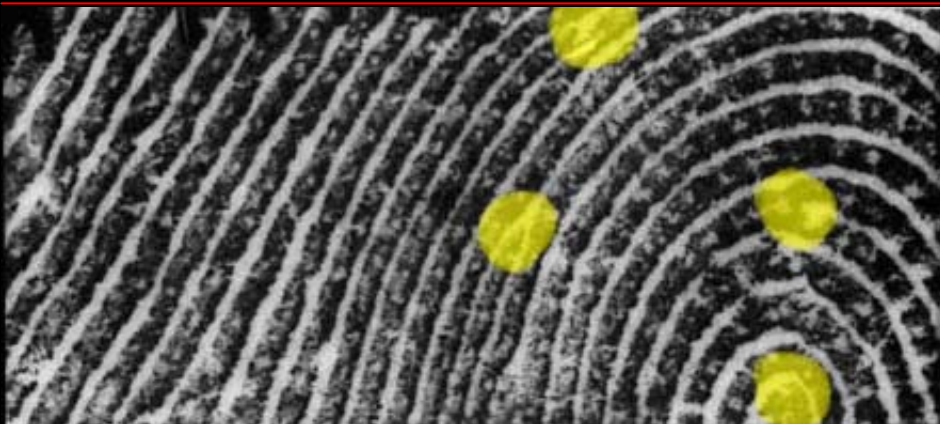
- A single ridge can be distinctive if all these factors are accounted for:
 - Continuity
 - Minutiae relationships
 - Curvature
 - Relationships of non-minutiae features

➤ ***Definition and detection both need research***

2b: Open Field of Ridges (1 of 2)



2b: Open Field of Ridges (2 of 2)

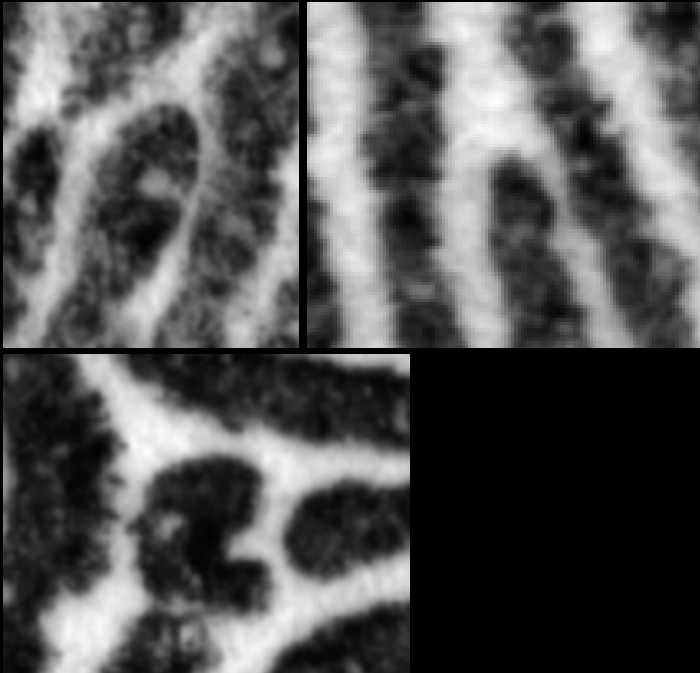


- A matcher has to know if the absence of marked minutiae is definitive: does a space without marked minutiae mean:
 - There are definitely no minutiae there OR
 - There may be minutiae there

- ***The absence of such information in IAFIS makes the system sensitive to prints with concavities or holes***
- ***Readily definable and automatically detectable***
- ***This can be bundled with the pattern definition (1a) – should it?***

2c: Greater definition of minutiae

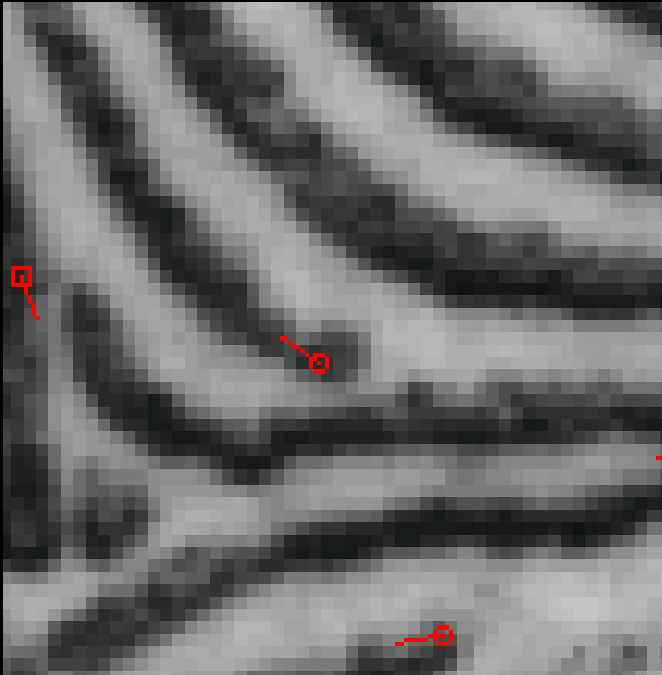
(1 of 3)



- Shape, size, and configuration of minutiae are distinctive
- Could use a finer level of description of the ridge ending shape and configuration of the actual bifurcation
- Use minutiae in addition to endings and bifurcations:
 - Crossovers
 - Trifurcations
 - (etc)

- **Definition:**
 - *Additional types of features reasonable*
 - *Shape of minutiae needs research*
 - *An interoperable definition would be worthwhile*
- **Detection needs research**

2c: Greater definition of minutiae (2 of 3)

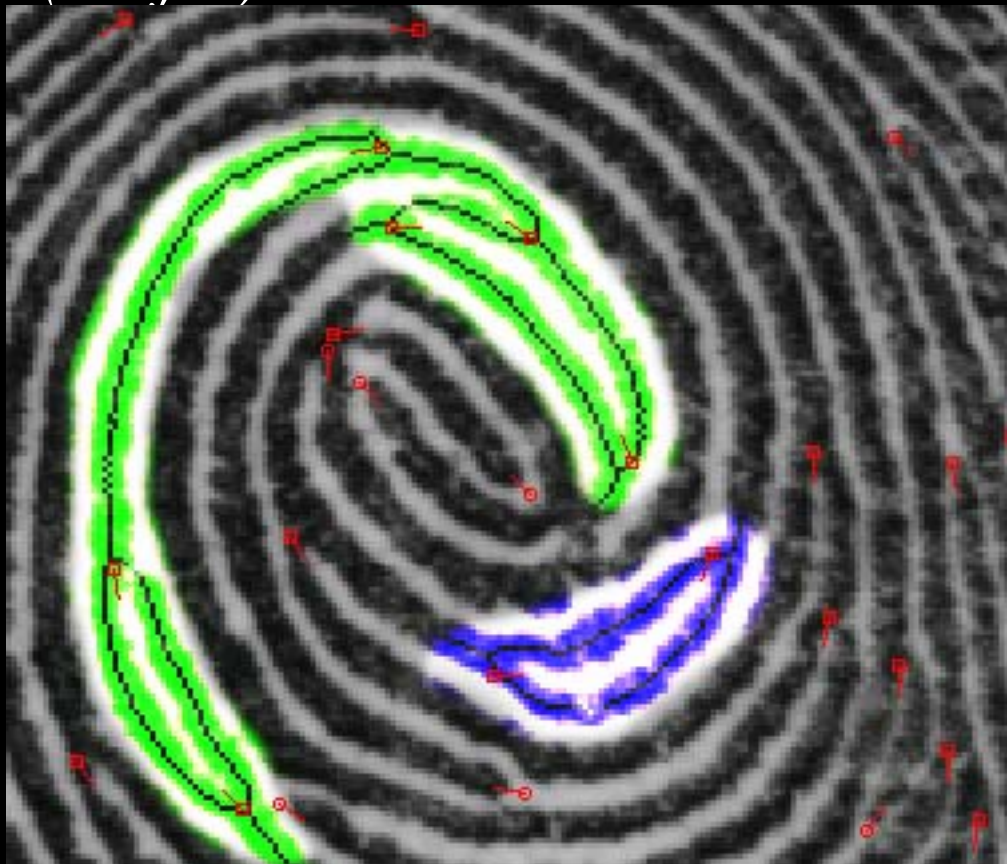


- Ridge endings can be defined in terms of
 - the fork of the tracing of the valley,
 - the end of the tracing of the ridge, and/or
 - the end of the ridge (e.g. the end of the binarized image) –
- Bifurcations can be regarded as the same definition with black-white reversal.
- Theta can be described in terms of different distances from the minutia location(s).

➤ ***Concurrence in definition is the hard part***

2c: Greater definition of minutiae

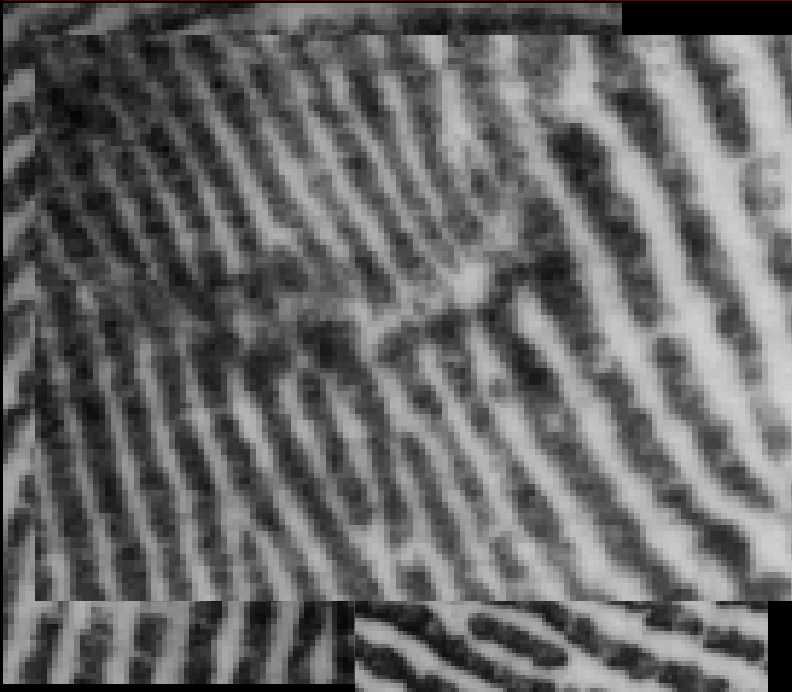
(3 of 3)



- Minutiae on same ridge need to be flagged
- Much richer interrelationships than simply ridge counts between neighbors
- Binarization and tracing already provide detection basis

➤ *Overlaps with ridge path (2a)*

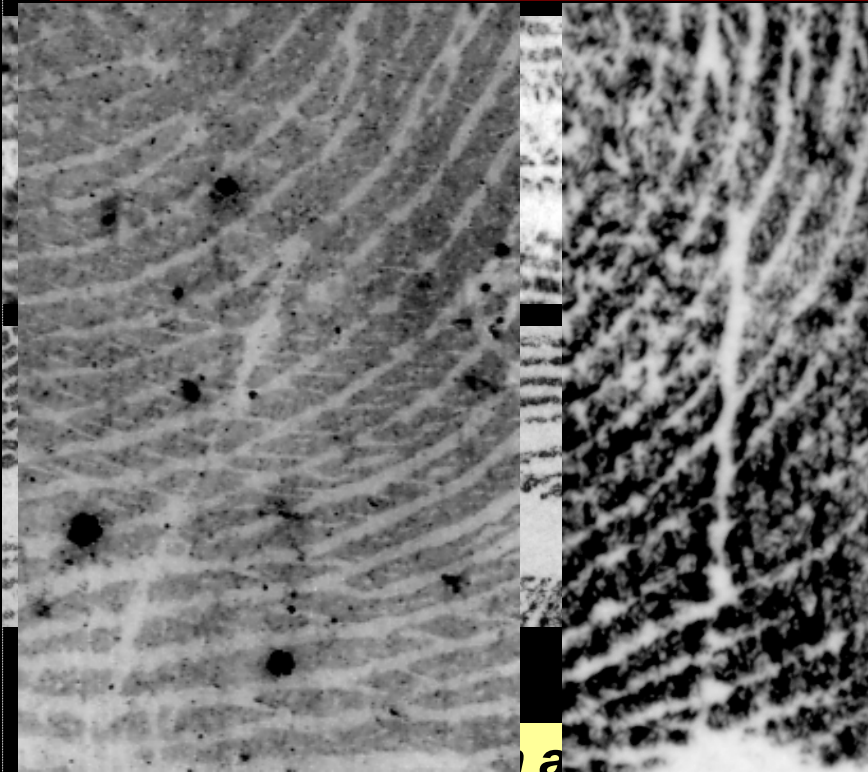
2d: Scars



- Presence, location, size, and configuration of scars can be very discriminating IF present in both images
- Linear ridge discontinuities could readily be defined and detected

- ***Hard: Definition and detection both need research***
- ***Concerns about consistency***
- ***Matching using scars needs to be fault-tolerant to account for the potential absence of the scar***

2e: Creases and Cracks



■ Creases

- between major fields of friction ridge skin (Flexure creases) are permanent and provide distinctive configurations of features (but vary between captures)
- within friction ridged area creases can be permanent or non-permanent.

- Flexure creases provide “feathering” which provides both location and direction to each aspect of the crease.

➤ *Hard Definition and detection need research*

➤ **Concerns about consistency**

2f: Incipient ridges



- Friction ridges not fully developed which may appear shorter, thinner in appearance, or more intermittent than fully developed friction ridges.
 - Rarely bifurcates
 - Rarely/never has pores
 - May appear at times as a series of dots
 - Shallower than ordinary ridges
- Often distinctive in propensity, presence, and location – to human examiners

- ***Definition and detection need research in determining how/whether to differentiate from standard ridges, or dots***
- ***Concerns about consistency***

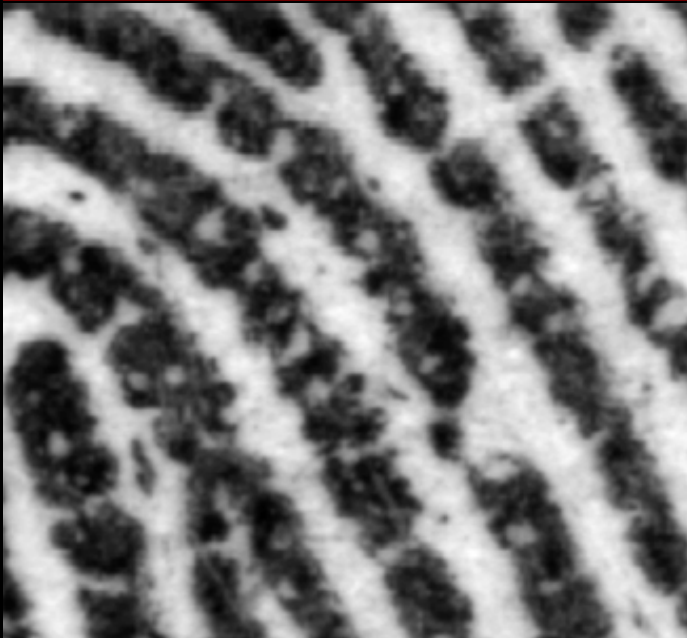
2g: Dots



- Dots, short ridges, and short enclosures are not generally used in IAFIS
- These are particularly distinctive

- *Readily definable and detectable*
- *Concerns about consistency*

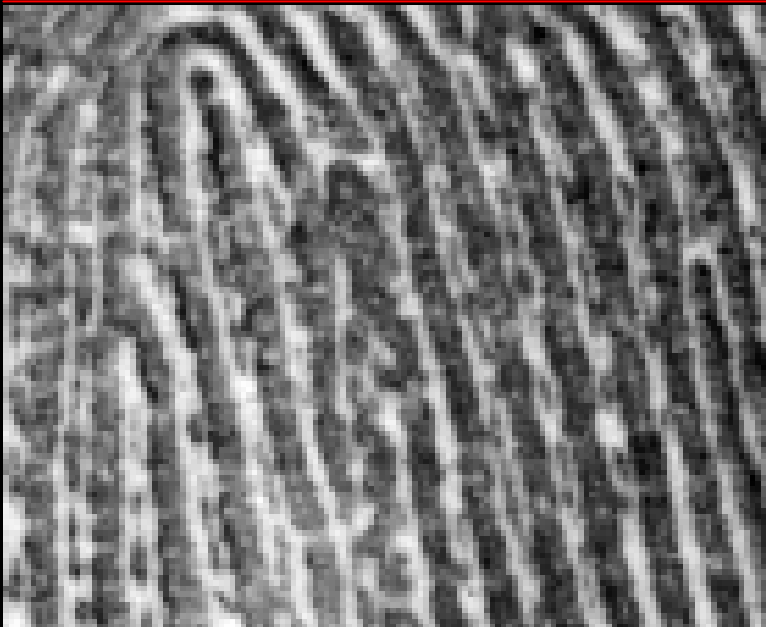
3a: Pores



- Pores are distinctive in several ways:
 - Size
 - Shape/form
 - Position on the ridge
 - Number or frequency
- Not always visible, especially in inked prints
- Resolution
 - Requires 1000ppi+ for full clarity
 - Can be useful as supporting evidence at 500ppi

- ***Definition and detection are practical given enough resolution***
- ***Concerns about consistency***
- ***See Roddy & Stosz 1999 IEEE paper “Fingerprint features statistical analysis” for discussion***

3b: Edge shapes



- Morphological features (width, major deviation, etc.) defining the contour or shape of the ridge edge
- Major deviations
 - indentations
 - protrusions
 - discontinuities
 - usable at 500 ppi (though obviously better at 1000+ppi)
- Edge features can be defined using Chatterjee's edge feature classification

- **Concerns about consistency**
- **Major deviations and discontinuities:**
 - *Definition and detection are probably both practical*
- **Other features:**
 - *Definitions can be based on Chatterjee*

➤

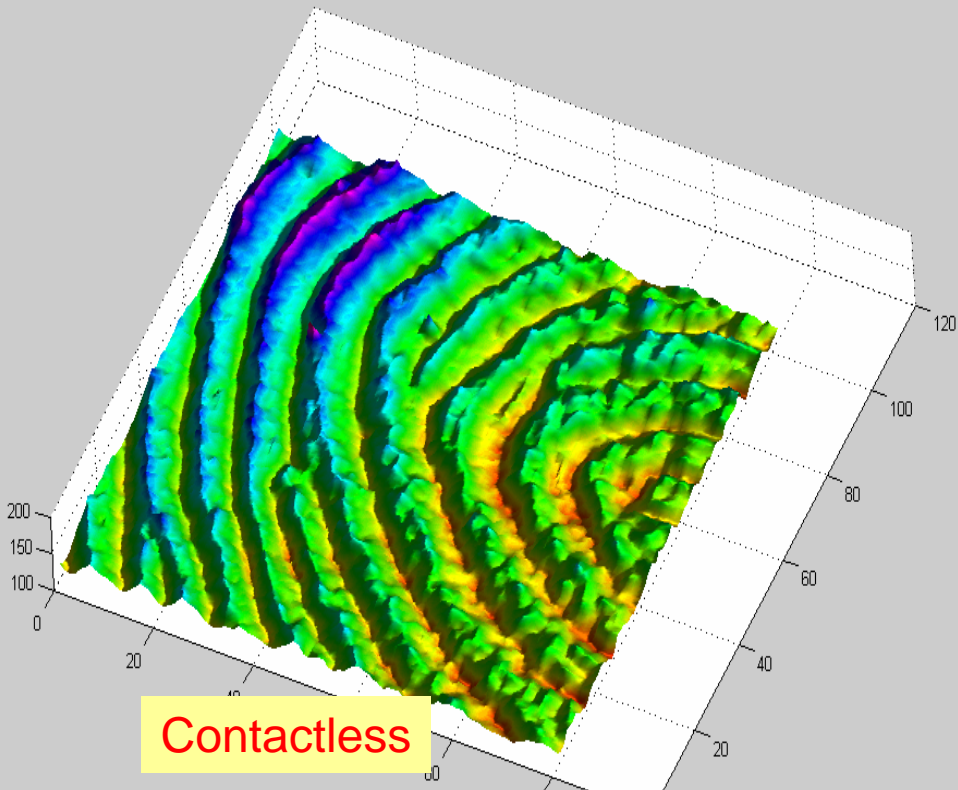
3c: Ridge/Valley width



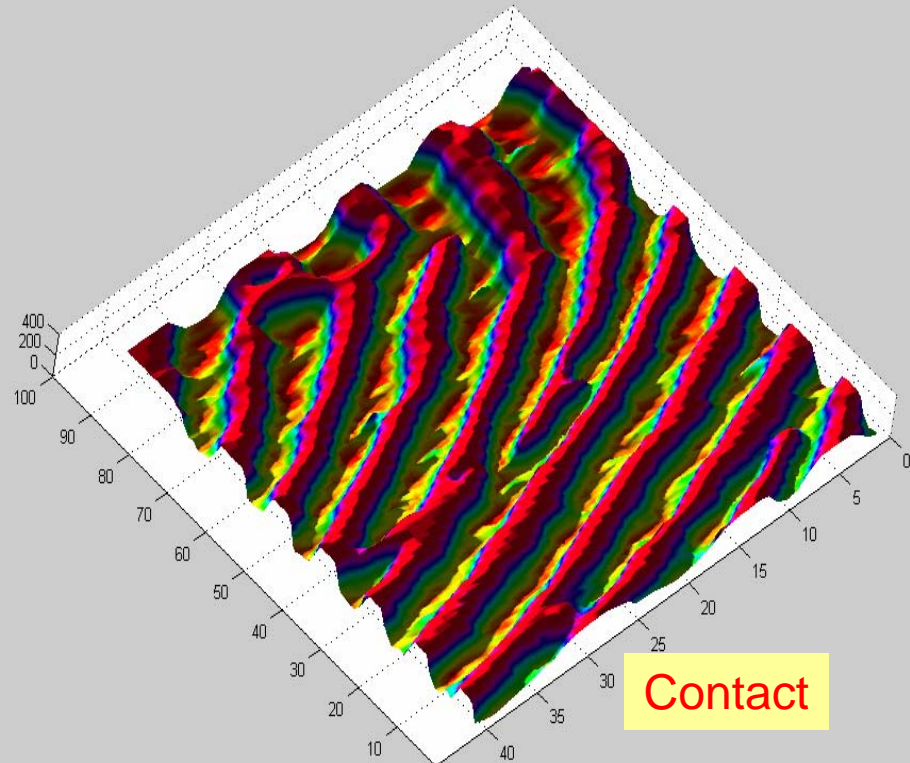
- Measurements from
 - Edge-to-edge of a ridge
 - Edge-to-edge of a valley
 - Center-to-center of adjacent ridges
- Special case of edge shapes (3b)
- Possible to define and detect:
 - Actual width of ridges and valleys at regular intervals
 - Major deviations in width
 - Discontinuities

- *May be practical to define and detect, even at 500ppi*
- *Concerns about consistency*

4a: Ridge Height / Valley Depth



Contactless



Contact

- *Is this beyond scope? Is 3d capture mature enough to define this yet? We should assume that this will need to be defined at some point.*
- *Concerns about consistency*

Next Steps

- Determining which features should be defined in the addendum
- Evaluation of consistency of presence/definition
- End products:
 - ANSI/NIST Addendum: Extended Fingerprint Features
 - White paper on lessons learned
 - Data sets with marked up examples (similar to NIST SD27)